

AERONET Direct Sun Algorithm – Version 2

Ancillary Data Set Corrections	Data Product	Spatial Resolution	Temporal Resolution	Source
NO ₂ [Reference 1]	Total column concentration [molec/cm ²]	Global: 0.25 x 0.25 degrees resolution	Monthly climatology (2003-2005)	ESA SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY)
O ₃ [Reference 2]	Total column concentration [Dobson Units]	Global: 1 x 1.25 degrees resolution	Monthly climatology (1978-2004)	NASA Total Ozone Mapping Spectrometer (TOMS): Earth Probe and Nimbus
Pressure [Reference 3]	Station pressure [hPa] derived from standard pressure level heights [m] and sea-level pressure by using quadratic fit in logarithmic space	Global 2.5 x 2.5 degrees resolution Six pressure level heights: sea-level, 1000, 925, 850, 700 600 hPa	Use 6-hourly when available and default to monthly climatology (1993-2004)	NCEP/NCAR Reanalysis
Corrections	Explanation		Implication	
O ₃ Absorption [Reference 4]	Integration of ozone spectroscopy and fitted to filter function for each wavelengths to obtain ozone absorption coefficients.		Improved ozone wavelength-dependent absorption correction	
NO ₂ Absorption [Reference 5]	Integration of NO ₂ spectroscopy and fitted to filter function for each wavelength to obtain NO ₂ absorption coefficients.		Improved NO ₂ wavelength-dependent absorption correction	
CO ₂ [Reference 6]	Constant value of 0.0089 at standard atmospheric pressure and temperature; adjusted by P/P _o .		Affects extended wavelength instruments (e.g., channel 1640nm)	
CH ₄ [Reference 7]	Constant value of 0.0036 at standard atmospheric pressure and temperature; adjusted by P/P _o .		Affects extended wavelength instruments (e.g., channel 1640nm)	
Filter Functions [Reference 8]	Filter functions have been updated for instruments after 1997.		Improved data quality.	
Optical Air Mass Formula [Reference 9]	Updated Kasten 1965 to Kasten and Young 1989.		Very small differences in air mass calculations at high solar zenith angles.	
Ozone Air Mass Formula [Reference 10]	Updated to Komhyr et. al. 1989.		The ozone layer is no longer fixed at 22km. The ozone layer height is adjusted by latitude to provide a more accurate representation of the ozone height layer.	
Water Vapor A and B Coefficients Recalculated [Reference 11]	Water vapor transmission (T_w) was modeled as $T_w = \exp[-A(mw)^B]$ using the radiative transfer code from Alexei Lyapustin. Constants A and B are unique to the particular filter and w is the vertical column water vapor content.		Improved water vapor calculations by up to 20%.	
Rayleigh [Reference 12]	Rayleigh equation suggested by Bodhaine et. al. (1999)		<0.001-0.007 change in the τ_R depending on latitude and elevation.	
H ₂ O [Reference 13]	Absorption optical depth computed for channels 1020 and 1640nm using instantaneous water vapor calculation (derived from the channel 940nm).		Affects channels 1020 and 1640nm.	
Earth-Sun Distance [Reference 14]	The effective V _o is calculated using the earth-sun distance correction.		Improved calculation of the effective V _o for each wavelength.	

References

- 1)
 - a) TEMIS – Tropospheric NO₂ from GOME and SCIAMACHY,
<http://www.temis.nl/airpollution/no2.html>
 - b) Eskes, H.J. and Boersma, K.F., 2004: Averaging kernels for DOAS total-column satellite retrievals, *Atmos. Chem. Phys.*, **3**, 1285-1291, 2003.
 - c) K.F. Boersma, H.J. Eskes and E.J. Brinksma, 2004: Error Analysis for Tropospheric NO₂ Retrieval from Space, *J. Geophys. Res.*, **109** D04311, doi:10.1029/2003JD003962, 2004.
- 2) Data were obtained from the NASA/GSFC TOMS Ozone Processing Team (OPT),
<http://jwocky.gsfc.nasa.gov/>.
- 3) Data were obtained from the NOAA National Weather Service NOMADS NCEP Server,
http://nomad3.ncep.noaa.gov/ncep_data/index.html.
- 4) Burrows, J. P., Richter, A., Dehn, A., Deters, B., Himmelmann, S., Voigt, S. and Orphal J., Atmospheric remote -sensing-reference data from GOME: 2. Temperature-dependent absorption cross sections of O₃ in the 231-794 nm range, *JQSRT*, **61**, 509-517, 1999.
- 5) Burrows, J. P., Dehn, A., Deters, B., Himmelmann, S., Richter, A., Voigt, S. and Orphal, J., Atmospheric Remote-Sensing Reference Data from GOME: Part 1. Temperature-Dependent Absorption Cross-sections of NO₂ in the 231-794 nm Range, *JQSRT*, **60**, 1025-1031, 1998.
- 6) Based on computation from standard US 1976 model.
- 7) Based on computation from standard US 1976 model.
- 8) N/A
- 9) Kasten, F. and Young, A. T., Revised optical air mass tables and approximation formula, *Appl. Opt.*, **28**, 4735-4738, 1989.
- 10) Komhyr, II'. D., Grass, K. D., and Leonard, R. K., Dobson Spectrophotometer 83: a standard for total ozone measurements, 1962-1987. *J. Geophys. Res.* 94:9847-9861, 1989.
- 11) Smirnov, A, Holben, B.N., Lyapustin A., Slutsker, I. and Eck, T.F., AERONET processing algorithms refinement, AERONET Workshop, May 10 - 14, 2004, El Arenosillo, Spain.
- 12) Bodhaine, B. A., Wood, N. B., Dutton, E. G., Slusser, J. R., On Rayleigh Optical Depth Calculations, *J. Atmos. and Ocean. Tech.*, **16**, 1854-1861, 1999.
- 13)
 - a) Schmid, B., Thome, K.J., Demoulin, P., Peter, R., Matzler, C., and Sekler, J., Comparison of modeled and empirical approaches for retrieving columnar water vapor from solar transmittance measurements in the 0.94 micron region. *J. Geophys. Res.*, **101**, 9345-9358, 1996.
 - b) Michalsky, J. J., J.C. Liljegren and Harrison, L. C: A Comparison of Sun Photometer Derivations of Total Column Water Vapor and Ozone to Standard Measures of Same at the Southern Great Plains Atmospheric Radiation Measurement Site, *J. Geophys. Res.*, **100**, 25995-26003, 1995.
- 14)
 - a) U.S. Naval Observatory, Astronomical Applications Department: Approximate Solar Coordinates, <http://aa.usno.navy.mil/faq/docs/SunApprox.html>
 - b) Michalsky, J., The astronomical almanac's algorithm for approximate solar position (1950-2030). *Solar Energy*, **40**, 227-235, 1998.